9.4: Muscular Responses

- Muscle contraction can be observed by removing a single skeletal muscle fiber and connecting it to a device that senses and records changes in the overall length of the muscle fiber.

Threshold Stimulus

- Threshold Stimulus
  - Minimal strength required to cause contraction

Recording of a Muscle Contraction

- Recording a Muscle Contraction
  - Twitch
    - Latent period
    - Period of contract
    - Period of relaxatio
  - Refractory period
  - All-or-none response

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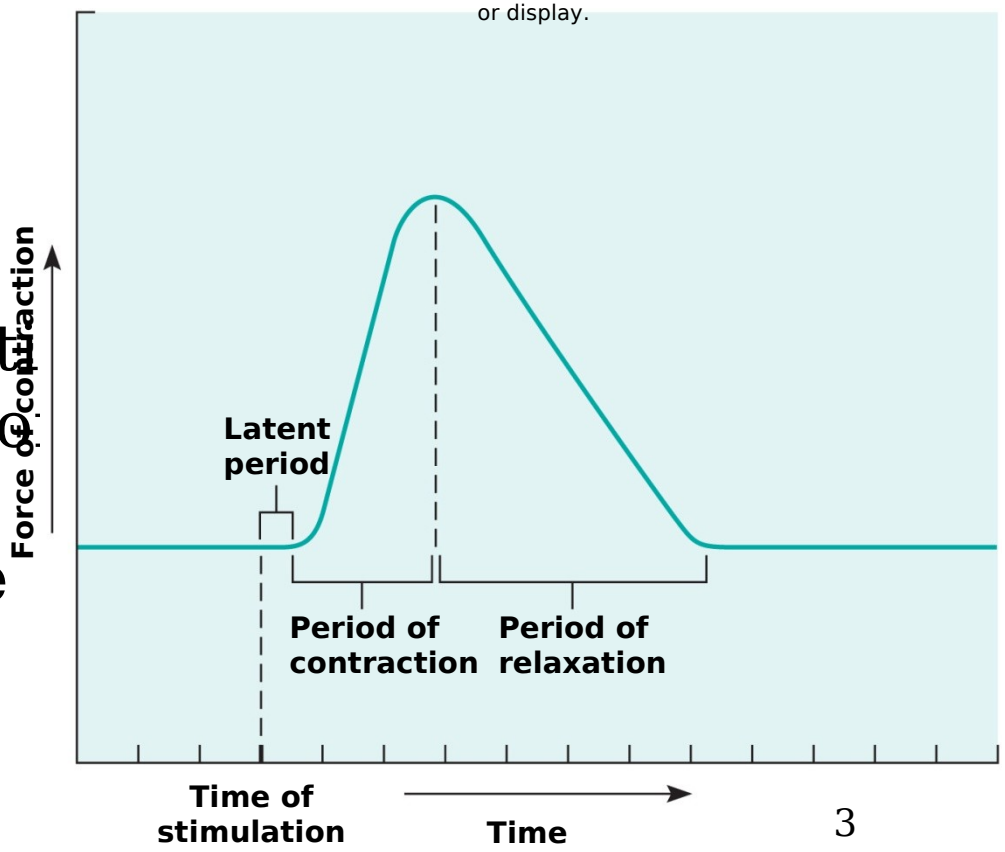

Length-Tension Relationship

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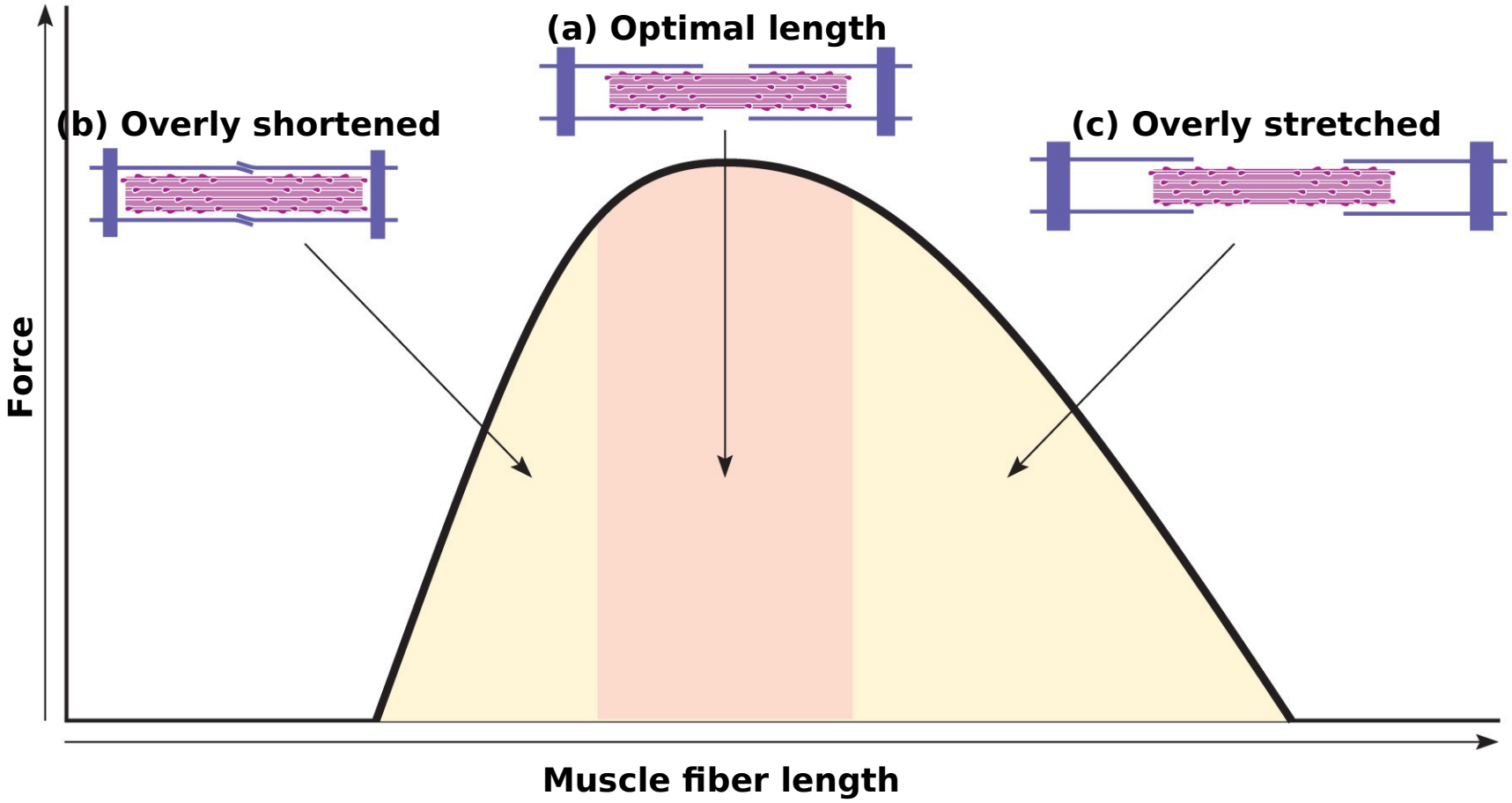

Summation

- Process by which individual twitches combine
- Produces sustained contractions
- Can lead to tetanic contractions

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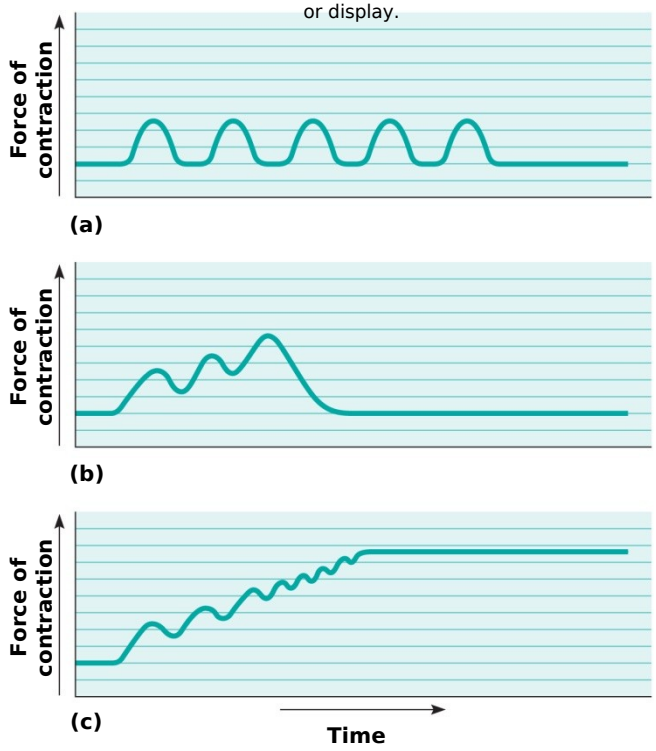

Recruitment of Motor Units

- Recruitment - increase in the number of motor units activated

- Whole muscle composed of many motor units
- More precise movements are produced with fewer muscle fibers within a motor unit
- As intensity of stimulation increases, recruitment of motor units continues until all motor units are activated

Sustained Contractions

- Smaller motor units (smaller diameter axons) - recruited first

- Larger motor units (larger diameter axons) - recruited later

- Produce smooth movements

- Muscle tone – continuous state of partial contraction

Types of Contractions

- Isotonic – muscle contracts and changes length

- Isometric – muscle contracts but does not change length

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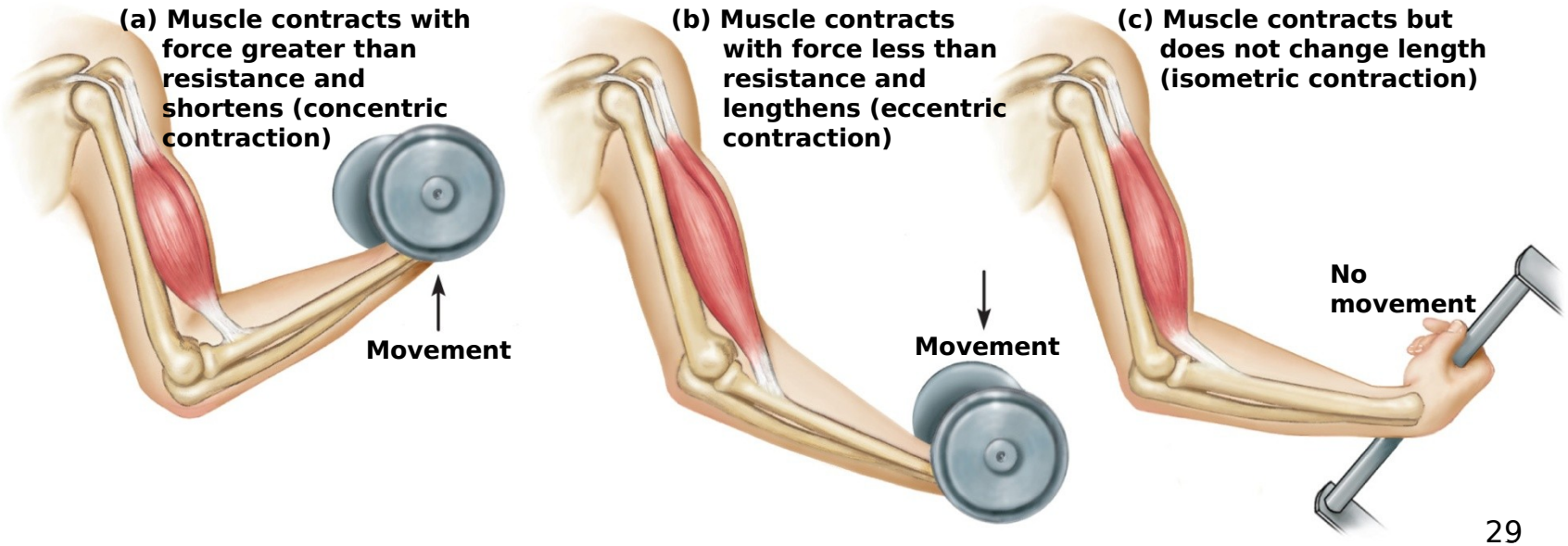
(a) Muscle contracts with force greater than resistance and shortens (concentric contraction)
Movement
(b) Muscle contracts with force less than resistance and lengthens (eccentric contraction)
Movement
(c) Muscle contracts but does not change length (isometric contraction)
No movement

Fast Twitch and Slow Twitch Muscle Fibers

- Slow-twitch fibers (Type I)
  - Always oxidative
  - Resistant to fatigue
  - Red fibers
  - Most myoglobin
  - Good blood supply
- Fast-twitch glycolytic fibers (Type IIa)
  - White fibers (less myoglobin)
  - Poorer blood supply
  - Susceptible to fatigue
- Fast-twitch fatigue-resistant fibers (Type IIb)
  - Intermediate fibers
  - Oxidative
  - Intermediate amount of myoglobin
  - Pink to red in color
  - Resistant to fatigue

9.5: Smooth Muscles

- Compared to skeletal muscle fibers, smooth muscle fibers are:
  - Shorter
  - Single, centrally located nucleus
  - Elongated with tapering ends
  - Myofilaments randomly organized
  - Lack striations
  - Lack transverse tubules
  - Sarcoplasmic reticula (SR) not well developed

Smooth Muscle Fibers

- Visceral Smooth Muscle
  - Single-unit smooth muscle
  - Sheets of muscle fibers
  - Fibers held together by gap junctions
  - Exhibit rhythmicity
  - Exhibit peristalsis
  - Walls of most hollow organs
- Multi-unit Smooth Muscle
  - Less organized
  - Function as separate units
  - Fibers function separately
  - Iris of eye
  - Walls of blood vessels

Smooth Muscle Contraction

- Resembles skeletal muscle contraction in that:
  - Interaction between actin and myosin
  - Both use calcium and ATP
  - Both are triggered by membrane impulses

  - Different from skeletal muscle contraction in that:
    - Smooth muscle lacks troponin
    - Smooth muscle uses calmodulin
    - Two neurotransmitters affect smooth muscle
      - Acetlycholine (Ach) and norepinephrine (NE)
    - Hormones affect smooth muscle
    - Stretching can trigger smooth muscle contraction
    - Smooth muscle slower to contract and relax
    - Smooth muscle more resistant to fatigue
    - Smooth muscle can change length without changing tautness